A high-resolution approach to evaluate the occurrence of varved sediments in Lake Walker, Québec North Shore, using image analysis and X-ray microfluorescence

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Introduction

- On the Québec North Shore, three lakes (lakes Pentecôte, Walker and Pasteur) were studied for the possible occurrence of laminated sediments. Facies analysis using CT-scan images and thin-sections of short sediment cores sampled along transects showed that lakes Pentecôte, Walker and Pasteur contain bioturbated, laminated and partially laminated sediments.
- It has been demonstrated that of the three studied lakes, Lake Walker is characterized by morphological factors (such as higher relative depth, mean depth, maximum depth, critical boundary and topographic exposure) that favour the preservation of sediment laminae. However, the existence of an annual rhythmicity has not been confirmed.
- Hence, the objectives of this study are to: (1) establish a depth-age model based on ^{14}C dating of an approx. 6 m composite section from Lake Walker, and (2) to conduct a microfacies analysis of the laminated sediments from that lake in order to confirm whether they are indeed varved.

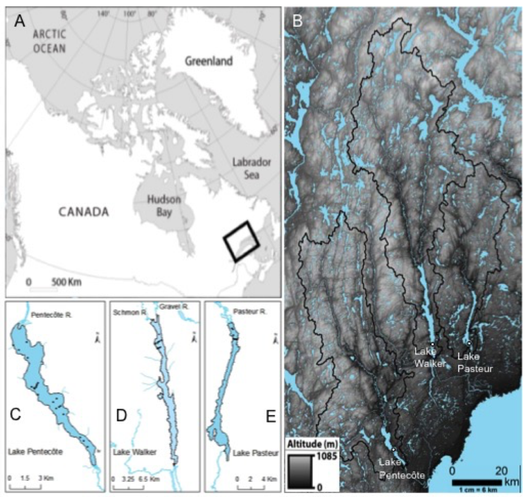

Fig. 1. (A) Geographic location of the Quebec North Shore region in northeastern Canada. (B) Location of lakes Pentecôte, Walker and Pasteur on the Quebec North Shore. The black line around each lake indicates the extent of their respective watershed. (C, D, E) .

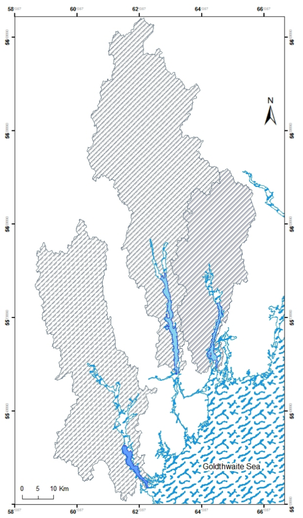

Fig. 2. Map showing the extent of the marine limit of the Goldthwaite Sea in the watershed (diagonal stripped area) of the studied lakes.

Methodology

- Fieldwork: Short sediment were collected in June 2014 and a composite sequence of long cores was collected in March 2015.
- Multibeam bathymetry and subbottom profiler data provided insight on the lake basin morphology and nature of sediment deposition
- Whole core sections were analyzed using a SIEMENS SOMATOM Definition Volume Access sliding gantry medical CT-scanner at (INRS-ETE).

Digital photography of split sediment cores were photographed with a GEOTEKTM Geoscan IV line-scan camera.

- X-ray microfluorescence was done using on an ITRAX™ core scanner (Cox Analytical Systems, Sweden) at INRS-ETE.

Fig. 3. Fieldwork, CT-Scan and ITRAX core scanner

Results

Relating the occurence of laminated sediments to lake morphometry

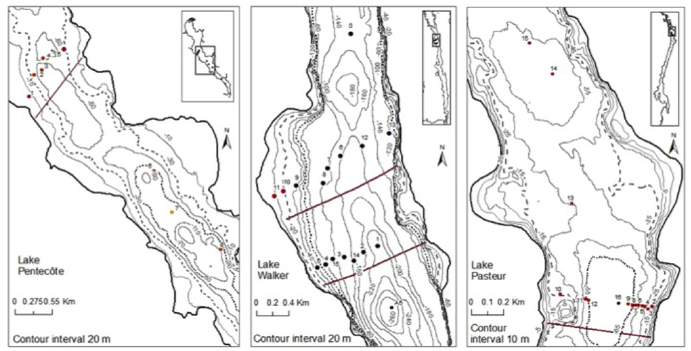

Fig. 4. Maps showing bathymetry, location of sampled sediment cores and the sediment facies described in (A) Lake Pentecôte, (B) Lake Walker and (C) Lake Walker. Also shown are contours that represents the approximate depth of the critical boundary (Zm_l = 71.5, 89.8, 72.5) and the maximum critical boundary (Zm_m = 71.5, 89.8, 72.5).

Table 1. Some characteristics of Lake Walker and the other studied

Lake	Latitude (°)	Longitude (°)	Basin area (km²)	Lake area (km²)	Maximum depth (m)	Altitude (m)
Pentecôte	49.867	-67.333	1748	18.9	130	88
Pasteur	50.217	-66.067	740	19.3	70	88
Walker	50.267	67.15	2187	41	280	119

Laminae visibility index

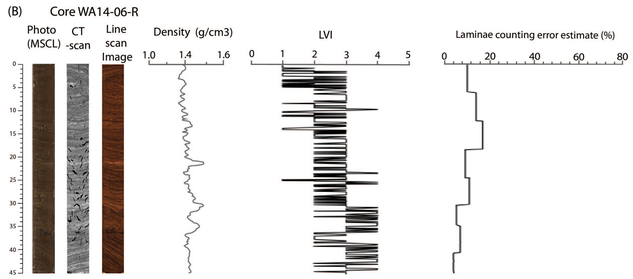

Fig. 5. Profiles with the digital photo, CT-scan image, line scan image ((ITRAX) and results of sedimentological analysis: laminae visibility index (LVI) and laminae counting error estimate of the reference cores from Lake Walker. LVI index: 0 – none, 1 – faint, 2 – visible, 3 – clear, ≥4 – distinct

Varve counting

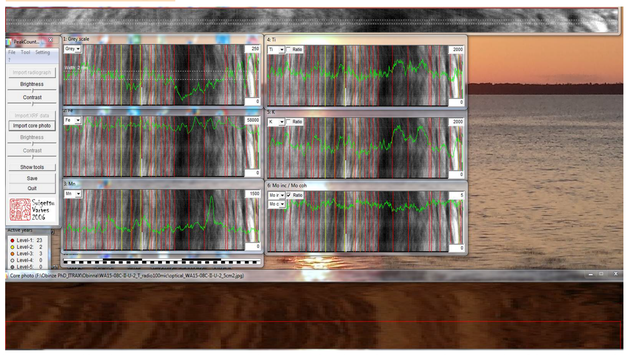

Fig. 6. Preliminary varve counting analysis of a 5 cm interval of laminated sediment from Lake Walker using the Peak counter 1.6.4 software (Nakagawa et al. 2002, 2007)

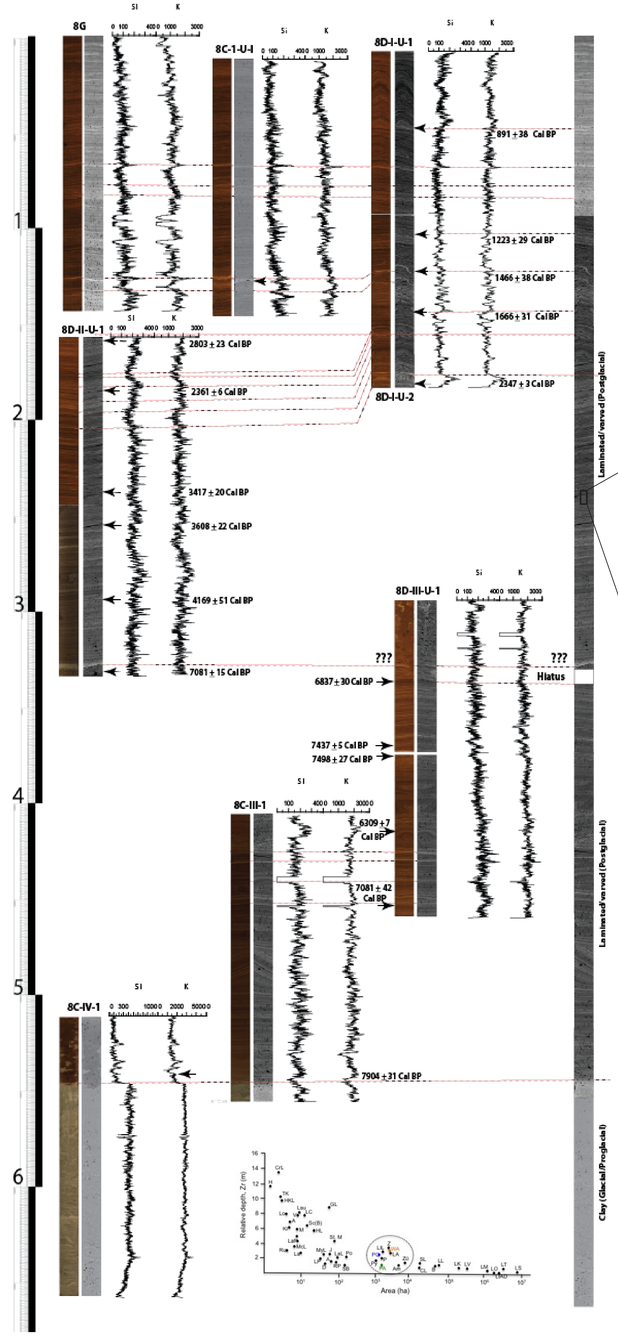

Fig.7. Composite section of cores from Lake Walker

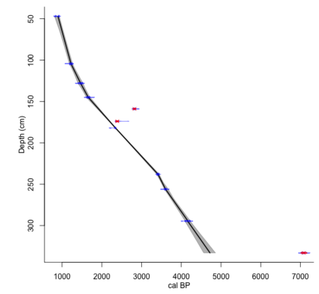

Fig. 8. Age-depth model of the upper laminated (approx. 320 cm) inteval from Lake Walker based on AMS radiocarbon dating

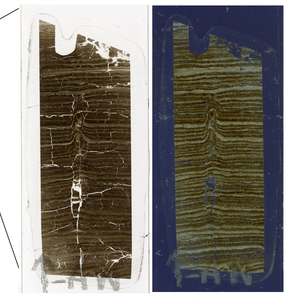

Fig. 8. Thin-section of varved sediment from Lake Walker seen in plane and cross-polarised light

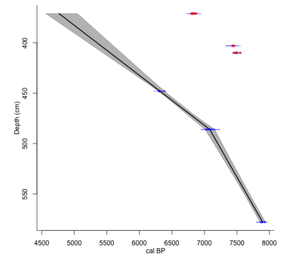

Fig. 8. Age-depth model of the lower laminated (approx. 180 cm) inteval from Lake Walker based on AMS radiocarbon dating

Summary and future work

- The application of previously reported heuristic assumptions in this study provides insights on the distribution and preservation of laminated sediments with respect to depth and lake morphometry.
- Image observation of lamination visibility of upper sediments from short sediment cores indicates that Lake Walker contains laminated lake sediments in high proportions, which are yet to be placed into an annual chronological framework in order to be sure that they are varved.
- The discovery of laminated sediments in high proportions within the sediments from Lake Walker is noteworthy. This lacustrine sequence contains varved and non-varved intervals with a basal age of 7904 ± 31 cal BP, and lies on top of pro-glacial sediments
- Therefore, Lake Walker is a promising archive for future varve-based paleoenvironmental reconstructions.

References

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